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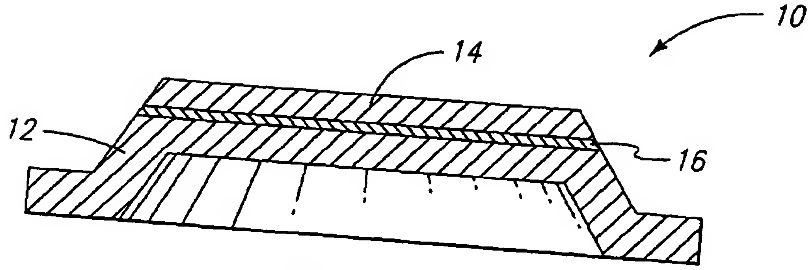

Fig 1

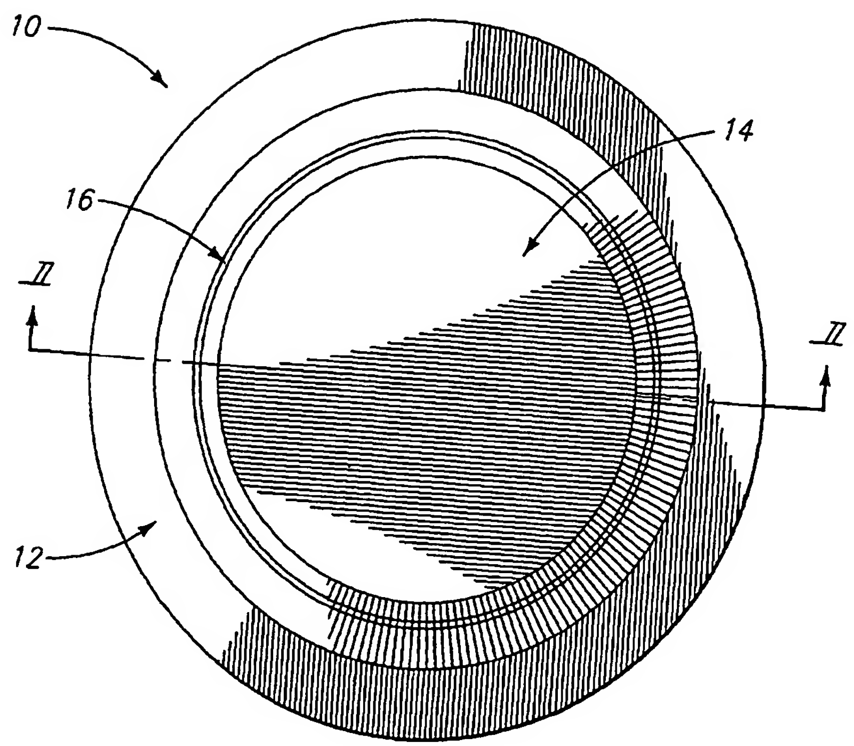

Fig 2

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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PROVISIONAL PATENT APPLICATION

* * * * *

PVD Targets Comprising Copper In Ternary Or Higher Order Mixtures, And Methods Of Forming Copper-Containing PVD Targets

* * * * *

INVENTORS

Brian J. Daniels
Michael E. Thomas
Christie J. Hausman
Michael R. Pinter
Susan D. Strothers
Wuwen Yi
Cara L. Hutchison
Anil S. Bhanap
Ananth Naman
Eal H. Lee

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PVD TARGETS COMPRISING COPPER IN TERNARY MIXTURES, AND METHODS OF FORMING COPPER-CONTAINING PVD TARGETS

TECHNICAL FIELD

[0001] The invention pertains to PVD targets comprising ternary or higher order copper-containing mixtures, and also pertains to methods of forming copper-containing PVD targets.

BACKGROUND OF THE INVENTION

[0002] Physical vapor deposition (PVD) (e.g., sputtering) is frequently utilized for forming films of material across substrate surfaces. PVD can be utilized in, for example, semiconductor fabrication processes to form layers ultimately utilized in fabrication of integrated circuitry structures and devices.

[0003] A typical PVD operation utilizes a target comprising a desired material. The target is provided within a chamber of an appropriate apparatus. A substrate is provided in a location of the chamber spaced from the target. Material of the target is then sputtered or otherwise dislodged from the target, whereupon the material deposits on the substrate.

[0004] In particular applications, targets comprise copper-containing materials, and are utilized to form conductive films across substrate surfaces. Exemplary applications for copper-containing conductive films are so-called dual damascene processes in which copper-containing conductive films are utilized to form electrical interconnects. In dual damascene processing, a substrate is provided which has trenches, vias, and/or other openings extending across its upper surface. Copper-containing films are sputter-deposited within the openings and over regions of the substrate between the openings. The copper

is then removed from the regions between the openings by, for example, chemical-mechanical polishing. The copper-containing film can be sputter-deposited to a sufficient thickness to completely fill the openings, but typically is not. Rather, the sputter-deposition is utilized to form a so-called seed layer of copper-containing material. The seed layer is a thin film upon which a remaining thickness of copper can be grown utilizing methodology other than sputter deposition, with exemplary methodology being electrochemical deposition. Thus, a copper-containing interconnect will typically comprise two portions. The first portion will be a thin film corresponding to the sputter-deposited seed layer, and the other portion (typically the majority or bulk of the interconnect) will by a layer formed over the seed layer by methodology other than sputter deposition.

[0005] Various difficulties can be encountered in utilizing PVD targets to sputter metal onto a substrate. The target can be subjected to intense power and heat, and can warp if it does not have sufficient strength to contend with the high powers to which the target is subjected to. Films deposited through a PVD process can have various problems associated with them if the composition of the film is not appropriate. For instance, metal-containing films can exhibit reduced lifetimes due to stress-induced migration, electromigration and/or corrosion. Additionally, the films can have other undesirable properties, such as poor adhesion to underlying materials of a substrate.

[0006] It would be desirable to develop target compositions which address one or more of the above-described problems, and it would also be desirable to develop methods for forming such target compositions.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Fig. 1 is a diagrammatic, cross-sectional view of an exemplary target/backing plate construction.

[0008] Fig. 2 is a top view of the Fig. 1 construction, with the cross-section of Fig. 1 extending along the line 1-1 of Fig. 2.

DETAILED DESCRIPTION

[0009] Interconnects based on copper technologies are replacing those based on aluminum technologies due to the lower electrical resistance of copper, improved electromigration resistance, and lower costs. However, similarly to aluminum, many properties of copper can be improved by small additions of other elements. Specifically, the use of alloys can reduce electromigration, stress migration, corrosion and other undesirable affects relative to pure copper. It can be advantageous to use ternary and higher order copper-containing conductive materials to address various problems, including, for example, problems associated with adhesion, stress migration, electromigration, oxidation resistance, etc., while still maintaining low overall electrical resistance of the conductive material containing the copper. For purposes of interpreting this disclosure, a mixture of copper and two additional elements is referred to as a ternary copper-containing mixture, and a mixture of copper and more than two additional elements is referred to as a copper-containing mixture having a higher order than ternary. The mixtures can be in any of numerous forms, including compounds, alloys, complexes, interspersed materials, etc. The mixtures utilized in the present invention are typically in the form of alloys, and in the discussion below the mixtures are referred to as alloys. It is to be understood,

however, that the mixtures can have other forms besides true alloys and accordingly the exemplary materials referred to as alloys in the discussion below can, in some aspects of the invention, have other forms besides true alloys.

[0010] A benefit of utilizing ternary or higher order alloys relative to binary alloys is that the ternary and higher order alloys can provide additional freedom for addressing specific problems. For instance, some elemental additions to copper primarily reduce electromigration, while others primarily reduce corrosion. Accordingly, when binary alloys are formed the alloys will typically be suitable for reducing electromigration, or suitable for reducing corrosion, but seldom are suitable for both. However, utilization of ternary or higher order alloys can allow both electromigration and corrosion to be addressed, and can also allow other undesirable effects to be addressed. Another benefit of utilizing ternary or higher order alloys is that the enhanced properties of more than one alloy can be combined to allow a longer target lifetime by forming the target to be stronger so that it can better hold-up at high powers. Thus, the utilization of ternary and higher order alloys can allow problems to be addressed with sputtering targets, and/or can allow problems to be addressed relative to films formed from sputtering targets.

[0011] One difficulty in utilizing ternary or higher order copper alloys is that it can be difficult to deposit a consistent composition as mixtures become increasingly complex. Each element of a mixture can have its own specific chemical quirks which can make it difficult to obtain appropriate chemical balances which consistently sputter-deposit in desired homogenous compositions.

[0012] A method of forming a target material comprising ternary or higher order mixtures of copper-containing materials can involve the following. Initially, the copper and other desired elements are cast by melting them in a crucible and subsequently cooling the molten material to form a hardened uniform (i.e., homogeneous) mixture of the copper and other desired elements. The casting would typically be conducted under a vacuum or other inert environment. Billets formed by the casting can then undergo appropriate working to induce desired properties, and can be formed into desired target shapes. The working can include, for example, thermomechanical processing with appropriate subsequent heat treatments tailored to specific alloy compositions. Additionally, or alternatively, the working can involve equal channel angular extrusion (ECAE) to reduce grain size and/or to influence a desired crystallographic orientation. The ultimate shape of the targets can be such that the targets are configured to be bonded to a backing plate, or can be such that the targets are configured to be utilized as monolithic targets.

[0013] Ternary and higher order copper-containing mixtures utilized in aspects of the present invention can have any suitable composition. In particular aspects, a copper-containing mixture will comprise, consist essentially of, or consist of copper together with two or more of Ag, Al, As, Au, B, Be, Ca, Cd, Co, Cr, Fe, Ga, Ge, Hf, Hg, In, Ir, Li, Mg, Mn, Nb, Ni, Pb, Pd, Pt, Sb, Sc, Si, Sn, Ta, Te, Ti, V, W, Zn and Zr. Exemplary compositions can consist of, or consist essentially of, from at least about 50 weight% copper to less than or equal to about 99.99 weight% copper, and two or more elements selected from the group listed above. A total amount of the two or elements present in the constructions with copper can preferably be from about 100 ppm, by weight, to less than about

10%, by weight. More preferably, the two or more elements can be present at from at least about 1,000 ppm to less than about 2%, by weight.

[0014] Exemplary ternary materials can comprise, consist essentially of, or consist of Cu/0.5at% Sn/0.5at% Al, Cu/0.5at% Sn/0.5at% In, Cu/0.5at% Sn/0.5at% Zn, Cu/0.3at% Ag/0.3at% Al, or Cu/0.3at% Ag/0.3at%Ti; where at% is atomic percent. In such materials, the silver can be utilized to improve electromigration resistance due to its fast diffusivity, low electrical resistivity, and high atomic weight. The titanium can be utilized for improving corrosion resistance, even though the titanium may increase electrical resistivity in the materials. The aluminum can be utilized for improving corrosion resistance, and may produce less degradation of electrical resistivity than the titanium.

[0015] Use of ternary or higher order copper alloys can permit customization of thin films formed from exemplary copper-alloy-containing targets of the present invention. For instance, the use of ternary or higher order copper alloys can permit customization of a sputter-deposited seed layer. Alloying elements can be chosen which impact seed layer properties such as, for example, adhesion to an underlying barrier material, agglomeration, stress migration, bulk copper diffusion, grain size, oxidation resistance, and electromigration resistance. Additionally, alloy elements can be chosen which impact interconnect properties through diffusion into a bulk copper material subsequently formed over the sputter-deposited seed layer. Positive aspects of element additions can be balanced while maintaining low electrical resistance. Ternary alloys can form improved interconnects relative to pure copper and binary copper-containing mixtures for at least the reasons that the ternary and higher complexes can simultaneously reduce stress-induced migration,

electromigration and corrosion, and can improve adhesion to underlying materials.

[0016] In addition to improving properties of layers sputter-deposited from a target, alloy additions to a copper-containing target may improve properties of the target itself relative to a target lacking the alloy additions. The improved properties can, include, for example, retardation of grain growth within the target material (to lead to better thin film uniformity from films formed from the target), and increasing of the material strength of the target, (which can enable the target to withstand higher sputtering powers).

[0017] An exemplary target construction which can be formed in accordance with methodology of the present invention is described with reference to Figs. 1 and 2. Specifically , the construction includes a target 14 bonded to a backing plate 12 through an interlayer 16. Target 14 can comprise ternary or higher copper complexes formed in accordance with the methodology described above. Backing plate 12 can comprise any suitable material, including, but not limited to, for example, low-purity copper. Interlayer 16 can constitute a diffusion bond formed directly between target 14 and backing plate 12, or can comprise one or more distinct materials provided to improve adhesion between target 14 and backing plate 12, with exemplary materials including, for example, one or more of silver, copper, nickel, tin and indium.

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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

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INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Brian J.	Daniels	La Honda, CA
Michael E.	Thomas	Milpitas, CA
Christie J.	Hausman	Spokane, WA

[X] *Additional inventors are being named on the* 1 *separately numbered sheets attached hereto*

TITLE OF THE INVENTION (280 characters max)

PVD Targets Comprising Copper In Ternary Or Higher Order Mixtures, and Methods of Forming Copper-Containing PVD Targets

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METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT *(check one)*

[ ] Applicant claims small entity status. See 37 CFR 1.27.

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[ ] Yes, the name of the U.S. Government agency and the Government contract number are: ____________

Respectfully submitted,

SIGNATURE ____________ Date 08/21/03

TYPED or PRINTED NAME David G. Latwesen, Ph.D.

REGISTRATION NO. *(if appropriate)* 38,533

TELEPHONE 509-624-4276

Docket Number: HO57-413

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INVENTOR(S)/APPLICANT(S)

Given Name (first and middle [if any])	Family or Surname	Residence (City and either State or Foreign Country)
Michael R.	Pinter	Spokane, WA
Susan D.	Strothers	Spokane, WA
Wuwen	Yi	Veradale, WA
Cara L.	Hutchison	Scotts Valley, CA
Anil S.	Ahanap	Milpitas, CA
Ananth	Naman	San Jose, CA
Eal H.	Lee	Milpitas, CA

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